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We examine the impact of sector-specific minimum wages in Germany on the willingness of youths to undergo vocational training. The theoretical intuition on the impact of wage floors on education is ambiguous. On the one hand, they raise the opportunity cost of education and prevent further skill accumulation. On the other hand, they lower the employment probability of unskilled workers, promoting additional training. Employing a mixed logit model, we estimate the probability of opting for an apprenticeship for a GSOEP-based sample of youths aged 17 to 24. Unlike the evidence from other countries, we find that increasing sectoral wage floors have a positive effect on training probabilities. Due to binding minimum wages, the demand for unskilled workers declines which lowers the opportunity cost of education. High requirements with regard to professional skills reinforce the effect.

JEL classification: C33, I21, I28, J24

Keywords: Minimum wages, education, vocational training, occupational choice, discrete choice

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1 Introduction

The introduction of the German statutory minimum wage in 2015 sparked an intense and controversial debate among politicians, scientists and labor market participants regarding its potential consequences. The proponents usually emphasize the argument of fairness since the number of *working poor* who rely on public support despite being employed has been on the rise since the mid-2000s (Eichhorst/Marx, 2011; Palier/Thelen, 2010). By contrast, the opponents worry about the country's position in the global economy. They argue along the lines that introducing a general minimum in a high-wage country might deal a death blow to Germany's competitiveness and destroy a large amount of flexible, low-wage job arrangements. However, comprehensive wage floors are not unknown to the German labor market. For two decades, unions and employers associations have been negotiating wage agreements on occupational levels which can legally be extended to non-members. These *generally binding collective bargaining agreements* have originally been used in industry and manufacturing sectors only. In the past ten years, the expansion of the service sector – which came along with an increasing number of low-wage jobs (Dustmann et al., 2009; Eichhorst/Marx, 2009; Palier/Thelen, 2010) – caused a more extensive use of sectoral minima in the services industry.

There is a vast body of literature on employment effects of minimum wages citing evidence from all over the world. However, less empirical work has been dedicated to the analysis of secondary impacts. Following the Human Capital Theory, the introduction of a statutory minimum wage affects educational decisions by increasing the opportunity cost of education so that individuals are encouraged to enter the labor market (Becker, 1964). Yet, taking account of the probability of finding employment, the argument can also be reversed. Since employers only want to hire workers whose productivity corresponds to the minimum wage level, the employment prospects of low-skilled workers decline. Thus, additional skill formation pays off in terms of an increased job finding probability and a higher wage beyond the general minimum. Given this trade-off, the educational effect of minimum wages is theoretically indeterminate (Checchi, 2006; Neumark/Wascher, 2010). Previous studies find strong evidence of a negative impact implying positive incentives to work for the minimum wage instead of accumulating further human capital (Chaplin et al., 2003; Hyslop/Stillman, 2007; Landon, 1997; Neumark/Wascher, 1995a,b, 2003; Pacheco/Cruickshank, 2007).

This paper examines the hitherto unknown effect of German sectoral minimum wages on the willingness of youths to undergo vocational training. Respective evidence is of major

political relevance. The dual apprenticeship system in Germany has the reputation to facilitate the school-to-work transition as it offers both formal professional schooling and on-the-job training and entails to a state-certified degree. The system covers a majority of occupations in all economic sectors and represents the standard type of non-academic vocational education in Germany (Büchel, 2002; Franz/Soskice, 1995; Thelen, 2004). Due to this special institutional role, we do not expect training incentives to be negatively affected by higher wage prospects. Nevertheless, in order to protect educational incentives, the statutory minimum wage law implies an exemption of underagers without completed vocational training. We thus contribute to the discussion of an exemption by providing fundamental evidence of a potentially distortionary impact of minimum wages with respect to professional skill accumulation. By combining data from the *German Socio-economic Panel* (GSOEP) and administrative data on sectoral minimum wage levels, we estimate a mixed logit model in order to analyze the probability of being an apprentice for a sample of youths aged 17 to 24 covering the years 1994 to 2014. Our main finding supports our hypothesis as we observe a greater probability of opting for apprenticeship training given rising sectoral minimum wages.

The remainder of this paper is organized as follows. Section 2 describes theoretical foundations and previous empirical evidence. Section 3 provides a brief overview on wage floor arrangements in Germany with a special emphasis on sectoral agreements. Section 4 introduces our methodological setup and the dataset employed. Section 5 presents the estimation results and section 6 finally concludes.

2 Theoretical Foundations and Previous Evidence

The basic approach that illustrates the relation of wages and beyond-compulsory skill formation is taken from Becker's 1964 Human Capital Theory. In simplified terms, all individuals are on a low skill level $q = l$ at the beginning of their working life in $t = 0$. They can choose between spending their time on educational activities – in order to reach a high skill level $q = h$ – or on unskilled work.[1] Education is costly in terms of training expenses[2] $C = cH_t$ and the foregone low-skilled wage W_t^l. Upon finishing their training, individuals receive the high-skilled wage $W_t^h > W_t^l$. The optimal decision

[1] Becker assumes that the total amount of time available cannot be split up in order to work and be trained in a part-time arrangement.

[2] Since training is assumed to be general here, the individual has to bear the cost, e. g. for classes or materials.

implies that the total cost of education equals the discounted future benefits of a higher skill level (Becker, 1964; Kellermann, 2017)

$$\sum_{t=1}^{T} \beta^t \frac{W_t^h - W_t^l}{(1+r)^t} H_t = (c + W_0^l) H_0. \tag{1}$$

With regard to minimum wages, we assume that a statutory minimum wage is binding for low-skilled workers only, $W_0^h > MW > W_0^l$. Thus, the opportunity cost of education rises for this group (Neumark/Wascher, 2010). Individuals are encouraged to spend time on full-time work which causes the labor supply to increase. Depending on the overall labor market situation, a potential consequence is an excess supply implying that individuals *queue* for a limited number of jobs. Therefore, this outcome is referred to as the *Queuing Hypothesis* (Kellermann, 2017; Neumark/Wascher, 2010) in relevant literature.

In general, the job finding probability ρ_i might be lower than 1 although Becker (1964) does not explicitly discuss this aspect. Taking account of employment prospects, the educational impact of minimum wages can also be positive. Workers are paid according to their level of productivity. Highly qualified workers are assumed to be preferred and thus already have a larger employment probability than low-skilled workers $\rho_h > \rho_l$. A minimum wage which is only binding for the low-skilled fosters another demand shift towards high-skilled workers. Thus, the employment probability rises for the high-skilled, $\rho_h^{MW} > \rho_h$ but declines for the low-skilled, $\rho_l^{MW} < \rho_l$. The minimum wage effect on employment probabilities might then outweigh the effect on income so that individuals have a larger incentive to participate in educational activities. This outcome is labeled the *Substitution Hypothesis* (Kellermann, 2017; Neumark/Wascher, 2010).

$$\rho_h^{MW} \sum_{t=1}^{T} \beta^t \frac{W_t^h - MW_t}{(1+r)^t} H_t > \rho_l^{MW} (c + MW_0) H_0. \tag{2}$$

Hence, in this scenario, the direction of the minimum wage impact depends on the relationship between the two opposing effects. If public intervention is strong, demand for low-skilled labor drops sharply. Thereby, the opportunity cost of education is considerably lowered and skill accumulation is promoted. However, if minimum wages exceed market wages by a considerable extent, strong incentives to work are set, which results in a reduction of educational activities.

In line with the Queuing Hypothesis, previous research mostly finds a discouraging educational impact of minimum wages. Ehrenberg and Marcus (1982) observe a negative effect on the individual probability to be enrolled in post-compulsory schooling for US teenagers from disadvantaged family backgrounds. The opposite effect is observed for youths from wealthier families (Ehrenberg/Marcus, 1982). Conducting several studies for the US, Neumark and Wascher (1995a, 1995b, 2003) confirm these observations. Given a 10% increase in the relative state minimum wage, the schooling probability of teenagers declines by 3.4%. In addition, the probability to be neither in school nor employed rises by 6.7%. Thus, a rising minimum wage causes both educational disincentives and a lower demand for youth labor. Examining the effect on the aggregate level, Chaplin et al. (2003) find that the share of students in post-compulsory schooling declines by about one percentage point given a minimum wage raise of 1.00 $.

Similar decreases in enrollment rates or schooling probabilities are observed in the Canadian, British and New Zealand labor market (Hyslop/Stillman, 2007; Landon, 1997; Pacheco/Cruickshank, 2007; Rice, 2010). For single demographic groups, there is no educational effect of minimum wages at all (Campolieti et al., 2005; Ehrenberg/Marcus, 1982; Landon, 1997). Thus, the negative impact dominates at least with regard to Anglo-Saxon countries, which are characterized by rather liberal labor markets and welfare regimes (Organization for Economic Cooperation and Development, 2017a,b). Likewise, the evidence suggests that legal exemptions, in terms of youth subminimum wages, effectively counteract the negative employment effects. In a cross-country analysis of OECD members, Neumark and Wascher (2004) observe that legal subminima increase the employment probabilities of affected youths by 1 up to 9 percentage points given a higher adult minimum. Regarding educational decisions, Pacheco and Cruickshank (2007) show that a raise in the legal teenage subminimum in New Zealand causes school enrollment rates to increase. The authors argue that the cost advantage over adult workers shrinks, which reduces the demand for teenage labor and in turn raises school enrollment.

3 Minimum Wages in Germany

Compared to other countries, the history of minimum wages in Germany is rather limited. Until the end of the 1990s, wage agreements that entailed public involvement were uncommmon. Unions and employers' associations fixed payment standards in a bargaining process on the occupation level or even firm level which originally covered only

union members (Dustmann et al., 2009). However, the German *Collective Agreement Act* allows to extend collective bargaining agreements to all workers in an occupational group or economic sector[3] which are then referred to as *generally binding agreements* (Antonczyk et al., 2010; Fitzenberger et al., 2011). If the negotiating parties decide on a payment standard, this can be considered an introduction of a sectoral minimum wage.

The first sectoral minimum wage, introduced in 1997, covered workers in German main construction trades[4]. Other sectors followed, e. g. the electrical trades and the painting sector. Since the process of collective bargaining was prevalently used in industrial sectors, the application of sectoral wage floors was limited to this part of the economy at first. However, since the beginning of the 2000s, sectoral minimum wages have also been applied in service sectors (see table 1). Promoted by the 2002 to 2006 labor market reform (*Hartz-Reform*), the growing number of flexible, atypical working contracts led to higher wage inequality and a rising number of *working poor* (Dustmann et al., 2009; Eichhorst/Marx, 2011; Palier/Thelen, 2010). Thus, wage floors in low-paid service sectors, such as care nursing, building cleaning or security services, have been used to address this issue. Since the economic performance of federal states in the former German Democratic Republic[5] still falls behind in terms of lower average wages and higher unemployment rates (see appendix figure B.1), most wage floors are regionally adapted. Strikingly, sectoral wage floors have not been observed to cause significant job losses among affected workers in West Germany. In East Germany moderate drops in employment are reported for painters and workers in the electrical industries (Boockmann et al., 2013; Frings, 2013; Möller, 2012; Rattenhuber, 2014).

Since January 1, 2015, the first statutory minimum wage is in effect. The vast majority of workers has been declared eligible for a gross hourly minimum of 8.50 € according to the *Minimum Wage Law*. On January 1, 2017, the statutory minimum was raised to 8.84 €. Despite the lack of scientific investigation of country-specific educational effects of minimum wages in Germany, protective measures have been adopted. The legislation comprises – among some others – an exemption of under-agers without a professional degree. According to official documentation, this declaration of ineligibility is intended

[3]This measure is bound to some preconditions. According to the Collective Agreement Act, the respective agreements must apply to a (non-defined) majority of workers even before the extension.

[4]The information on sectoral minimum wages is taken from the respective legal regulations published in the German Federal Gazette.

[5]These include Berlin (East), Brandenburg, Mecklenburg-Vorpommern, Saxony, Saxony-Anhalt and Thuringia.

Table 1: Sectoral Minimum Wages in Germany

Occupational Group	Year of Introduction	Current Level in €[a]
Agriculture, Gardening & Forestry	2015	8.60
Building Cleaning	2007	10.00 (West), 9.05 (East)[c]
Butchery	2014	8.75
Care Nursing	2009	10.20 (West), 9.50 (East)
Chimney Sweep Trades	2014	12.95
Electrical Trades	1997	10.65 (West), 10.40 (East)
Hair Dressing	2013	8.84 (statutory minimum)[d]
Hard Coal Mining	2009	8.84 (statutory minimum)[d]
Main Construction Trades	1997	11.30
Laundry Services	2009	8.75
Painting & Varnishing	2003	13.10[b] (West), 11.30[b] (East)
Postal Services	2007	abolished in 2010
Professional Education	2012	14.60
Roofing	1997	12.25
Scaffolding	2013	10.70
Security Services	2011	8.84 (statutory minimum)[d]
Stone Cutting	2013	11.35 (West), 11.00 (East)
Subcontracted Work	2012	8.84 (statutory minimum)[d]
Textile Industry	2015	8.84 (statutory minimum)[d]
Waste Management	2010	9.10

[a]January 1, 2017; [b]For skilled workers; [c]Higher wage levels of 13.25 (West) and 11.53 (East) for specialists in window cleaning; [d]No sectoral minimum wage in use at the moment, negotations might still continue

to preserve both training incentives and opportunities. School-leavers should not feel encouraged to leave the educational path and enter the labor market in order to earn the minimum wage. At the same time, employers should have no incentive to abstain from hiring still unskilled youths and offering them vocational training.[6] However, with regard to the institutional setting of the German labor market, the resulting question is whether incentives for professional education need to be protected from a minimum wage distortion. The German apprenticeship system is widely accepted and used as the standard option to obtain non-academic occupational skills for a majority of occupations. The system is referred to as the ideal prototype of a smooth transition from school to work. Combining both vocational schooling and employer-financed job training, it produces qualified professionals with good job prospects. Skills acquired during an

[6]The Federal Ministry of Labor and Social Affairs published a respective statement on its official webpage, see Federal Ministry of Labor and Social Affairs, 2014.

apprenticeship are firm-specific only to a limited extent so that they can be applied in several employments in the same occupational group. This transferability positively stimulates the willingness to be trained (Büchel, 2002; Eichhorst/Marx, 2009).

Furthermore, the apprenticeship system shapes the general skill level in an occupational group. Due to the commonness of vocational training, most workers are skilled and an official degree is required to carry out many professions, especially in the industrial sector. Hence, the employment probability of unskilled workers is relatively low because there is a sufficiently large skilled workforce to meet firms' labor demand. In case of a rising minimum wage, firms can substitute unskilled with skilled workers or with apprentices who then obtain required professional qualifications (Acemoglu/Pischke, 1998; Eichhorst/Marx, 2009). In consequence, the Substitution Hypothesis as outlined above is more likely to be applicable to this context. In addition, apprentices in Germany are in fact paid a wage so that vocational training does not imply a complete loss of earned income. This offsets the rising opportunity cost of education to a certain extent (Büchel, 2002; Franz/Soskice, 1995; Thelen, 2004).

Finally, it has to be clarified that there is and has been no exception of youth workers from sectoral minimum wages. Obviously, no significant distortions of educational incentives have been expected by policy-makers. Thus, we suppose that increases in sectoral minimum wages do not discourage school-leavers from participating in the well-established and encompassing system of vocational training. This is to be investigated in the following.

4 Estimation Strategy

Our empirical analysis is based on micro-level data taken from the GSOEP version 31.[7] Since the first sectoral minimum was only introduced in 1997, the dataset is restricted to the period from 1994[8] to 2014. The sample used contains data on youths aged 17 to 24 excluding individuals who already completed professional training and those for which no information on occupational activities is available. Furthermore, observations for youths with a higher secondary degree are omitted. The German secondary school system consists of a higher, a medium and a lower secondary track where only graduating from the higher track qualifies for university acceptance. Hence, it is assumed that the higher

[7] For an earlier version of this study, see Kellermann, 2017.
[8] The starting year is 1994 because of the included lagged variables, see below.

track is followed intending to undergo academic education rather than vocational training at a later stage. Moreover, jobs for academics are unlikely to be affected by minimum wage standards. These ommittances leave us with a dataset of 8,977 observations in the baseline model.

The question of interest is whether an individual makes her decision to undergo professional training based on the level of the sectoral wage floor. The set of alternatives comprises two options since a school-leaver without the appropriate certification to follow an academic track can voluntarily choose between apprenticeship training or unskilled employment. This is identical to a choice between being paid a below-market and below-minimum training compensation or the sectoral minimum wage. Hence, the resulting dependent variable *Educational Status* is binary and takes a value of 1 if an individual is currently doing an apprenticeship and 0 if an individual is an unskilled full-time or part-time worker. This approach only examines the vertical occupational decision, that is whether accredited professional skills are accumulated, but not the horizontal choice regarding the occupational field itself, which is assumed to depend on other factors, e. g. personal interests or talents.

Since the GSOEP does not provide data on sectoral minimum wages, the respective information is extracted from the official declarations of general application of collective bargaining agreements. The matching process of wage floors and individuals is based on the 1992 classification of occupations by the Federal Statistical Office (FSO). The current job title of an individual given by the GSOEP is compared to the job titles which are declared eligible for a sectoral minimum according to the legislations. If they correspond, the observation is matched with the respective gross hourly sectoral minimum in use on January 1 of the observation year (see appendix table B.1).[9] To measure the degree of affection, we follow previous studies, in particular those by Neumark and Wascher (1995a, 1995b, 2003). The sectoral minimum is divided by the gross hourly median wage of all workers in the individual's home state. This relative minimum wage, the so-called *Kaitz Index* (Landon, 1997; Neumark/Wascher, 1995a,b, 2003; Rice, 2010), serves as the main explanatory variable. Pre-analysis employing Dickey-Fuller tests shows that the wage series mostly contain a unit root (see appendix figure B.2). In order to achieve an unbiased estimation, the Kaitz index is replaced by its first difference. This procedure is preferred over taking logs so that observations with a minimum wage of zero do not

[9]Minimum wages prior to the introduction of the € in 2002 are converted at the official rate fixed by the European Council.

get lost. Finally, for the purpose of modeling a certain delay in reactions to minimum wages, we include the one-, two- and three-period lags of the first Kaitz difference.

The estimation is conducted employing a mixed logit model which is especially valid for the analysis of discrete choices. Coefficients are calculated via maximum likelihood estimation. For every cluster-level of observations, the model produces a random intercept η_i which captures level-specific variation, e. g. tastes, preferences and similar unobservable effects that do not vary over time. Furthermore, by that, a variety of data particularities are adressed such as serial correlation and a lack of independence of irrelevant alternatives[10] (Hensher/Greene, 2003; Revelt/Train, 1998). Another main concern is that the estimates might suffer from a selection bias since our sample is not randomly selected. Applying a Heckman correction model as a standard methodology to account for sample selection, however, is only feasible in cross-section settings. With panel data, mixed regression techniques might again be used to produce valid estimates as the sample selection bias is absorbed by the random intercept (Grilli/Rampichini, 2007; Miranda/Rabe-Hesketh, 2006). We furthermore apply an endogenous switching model from the class of Generalized Linear and Latent Mixed Models (GLLAMM)[11] which allows to control for self-selection into a minimum wage sector as a first step to compute the unbiased minimum wage impact on the educational decision afterwards (Miranda/Rabe-Hesketh, 2006). Our model setup thus requires to maximize the apprenticeship probability (Hensher/Greene, 2003; Kellermann, 2017)

$$P_{it} = \int L_{it} f(\eta|\Omega) d\eta \tag{3}$$

with the likelihood function

$$L_{it}(\eta) = \frac{exp(\alpha + \sum_{k=0}^{3} \beta_k \Delta Kaitz_{it-k} + \gamma \boldsymbol{X_i} + \delta \Delta \boldsymbol{Z_{t-1}} + \lambda_t + \eta_i)}{1 + exp(\alpha + \sum_{k=0}^{3} \beta_k \Delta Kaitz_{it-k} + \gamma \boldsymbol{X_i} + \delta \Delta \boldsymbol{Z_{t-1}} + \lambda_t + \eta_i)}. \tag{4}$$

[10] Although the observed group of school-leavers does not face other choices than apprenticeship training or unskilled work, a dependence on academic training cannot completely be excluded. For example, a general shift towards a higher skill level could encourage school-leavers with lower secondary degrees to do an apprenticeship in order to keep up with the overall trend. Perfoming Wald tests and Hausman tests confirm that the null hypotheses of homoskedastic residuals and independence of irrelevant alternatives can both be rejected at a 0.1% level of significance.

[11] Computational techniques are similar to those of a mixed logit model. For an exact description of GLLAMM, see Skrondal/Rabe-Hesketh, 2004.

Table 2: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Educational Status	8,977	0.81	0.392	0	1
in Minimum Wage Groups	1,022	0.854	0.353	0	1
in Other Occupational Groups	7,955	0.805	0.397	0	1
Δ Kaitz Index	8,977	0.037	0.176	-0.83	0.9
Sex	8,977	0.433	0.496	0	1
Nationality	8,063	0.125	0.331	0	1
Age	8,977	20.196	1.925	17	24
Secondary School Degree	8,977	1.555	0.59	0	2
Required Education for Occupation	7,569	4.327	1.196	1	6
Region of Residence	8,977	0.253	0.435	0	1
Δ State Unemployment Rate	7,813	-0.057	1.139	-13.1	11.7
Δ Number of Apprenticeship Places	7,279	-0.377	29.591	-37.764	93.848
Δ Relative Youth Cohort Size	8,977	0.158	0.351	-0.156	0.961

The variable $\Delta Kaitz_{it-k}$ refers to the lags of the first difference of relative sectoral minimum wages. We control for a vector of common demographics $\boldsymbol{X_i}$, which are *Sex* and *Nationality* (Campolieti et al., 2005; Chaplin et al., 2003; Neumark/Wascher, 1995a,b, 2003) as well as an indicator for the obtained *Secondary School Degree* measured as medium, lower or no degree (Kellermann, 2017). Furthermore, in order to take the competitive situation on the labor market into account, we use a vector of macro-level controls $\boldsymbol{\Delta Z_{t-1}}$. These are *Relative Youth Cohort Size* as percentage of the entire population (on the national level), *State Unemployment Rate* in percent of civil employees and the absolute *Number of Apprenticeship Places* offered by firms in thousands (on the national level), all of which are also included as one-period lagged first differences in order to achieve stationarity. In addition, we control for time effects.

Descriptives are given in table 2.[12] As expected, the fraction of apprentices is higher than 0.8 in both minimum and non-minimum sectors, indicating that professional training is by far the likelier choice than unskilled work. Figure 1 presents the shares of apprentices in minimum and non-minimum sectors over time. No clear difference can be determined by means of visual inspection. In figure 2, the educational status is plotted against the lags of the first Kaitz difference. Looking at the first three subplots in particular suggests a small positive link between the educational status and minimum increases.

[12] A more detailed description of the dataset can be found in appendix A. For correlation and collinearity diagnostics, see tables B.2 and B.3 in appendix B.

Figure 1: Apprenticeship Probability by Year and Occupational Group

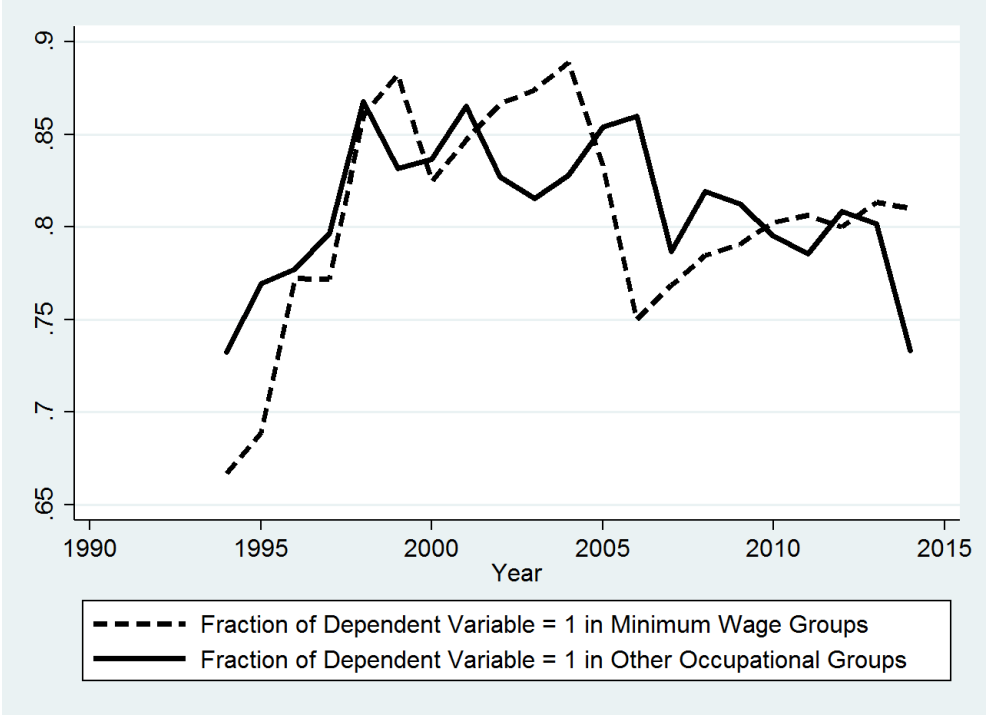
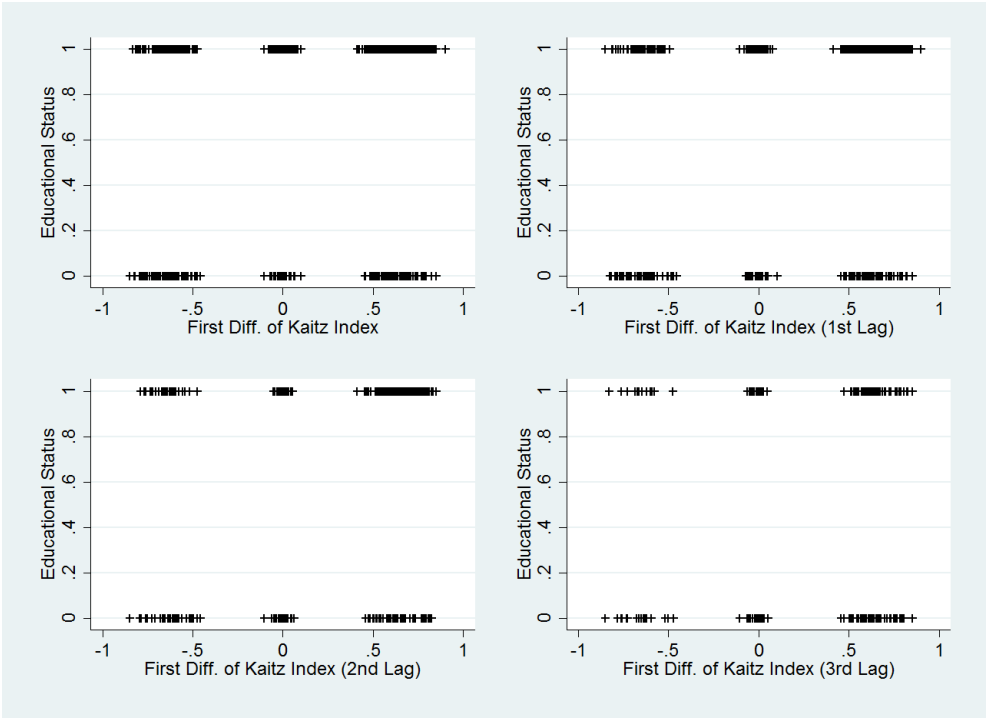


Figure 2: Plot of Educational Status against Explanatory Variables



5 Empirical Results

Baseline Regression Baseline regression results are reported in table 3. The minimum wage impact is positive and significant on a 1% level up to the second lag. Both the one- and two-period lagged Kaitz differences yield larger estimates than the Kaitz difference in t which is plausible with regard to the fact that educational decisions as a reaction to minimum changes can only be realized with a certain delay. The three-period lagged Kaitz difference produces no significant coefficients. Adding control variables, the estimates remain significantly positive showing the same time pattern. Thus, an increase in sectoral minimum wages induces a higher probability of vocational training.

Table 3: Baseline Regression Results

Dep. Variable: Educational Status	(1)	(2)	(3)	(4)	(5)	(6)
	Mixed Logit		GLLAMM		Multinomial Probit	
Δ Kaitz Index	1.294***	1.019***	0.511***	0.605***	0.439***	0.590***
	(0.313)	(0.293)	(0.108)	(0.156)	(0.133)	(0.189)
$(\Delta$ Kaitz Index$)_{t-1}$	2.050***	1.748***	0.941***	1.000***	1.023***	1.112***
	(0.436)	(0.409)	(0.147)	(0.185)	(0.190)	(0.233)
$(\Delta$ Kaitz Index$)_{t-2}$	1.827***	1.616***	0.915***	0.839***	0.980***	0.894***
	(0.540)	(0.504)	(0.187)	(0.208)	(0.251)	(0.268)
$(\Delta$ Kaitz Index$)_{t-3}$	0.336	0.304	0.143	0.0717	-0.0253	-0.101
	(0.652)	(0.605)	(0.229)	(0.253)	(0.322)	(0.337)
Sex: Female		-0.355**		-0.0886*		-0.146**
		(0.145)		(0.0464)		(0.0624)
Nationality: Non-German		-1.398***		-0.386***		-0.570***
		(0.201)		(0.0677)		(0.0975)
Secondary Degree: Lower		1.769***		0.476***		0.719***
		(0.330)		(0.108)		(0.178)
Secondary Degree: Medium		3.161***		0.902***		1.301***
		(0.331)		(0.108)		(0.176)
$(\Delta$ State Unemployment Rate$)_{t-1}$				0.0125		0.0172
				(0.0202)		(0.0368)
$(\Delta$ Number of Apprenticeship Places$)_{t-1}$		0.0577***		-0.000295		-0.000860
		(0.0168)		(0.000772)		(0.00983)
$(\Delta$ Relative Youth Cohort Size$)_{t-1}$		-0.121		-0.0262		-0.636**
		(0.415)		(0.0715)		(0.304)
Constant	3.268***	0.488	4.268	29.60***	0.821***	0.701***
	(0.266)	(0.374)	(5.193)	(10.45)	(0.0876)	(0.214)
Random Intercept (Std. Dev.)	1.229***	0.935***	-0.221***	-0.179**		
	(0.0351)	(0.0352)	(0.0716)	(0.0903)		
Observations	8,977	6,877	11,484	11,484	8,977	5,056
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; observations are clustered at the individual level.
Columns (3) and (4) provide results of a GLLAMM-based endogenous switching model. In the switching model (not shown here), a binary indicator of working in a minimum wage sector (y/n) is determined by individual characteristics and time trends. At the second stage, the apprenticeship probability is estimated as described.
Time effects in the GLLAMM model are included as time trends.

In column (3) and (4) of table 3, the results from estimating a random-intercept logistic model from the category of generalized linear latent and mixed models (GLLAMM) are reported. Another suitable approach is to specify a multinomial probit model which

also allows for any correlation between the error terms but without calculating a person-specific random intercept. The respective estimation results are displayed in columns (5) and (6) of table 3. Consistent with the mixed logit estimation, the minimum wage impact is significantly positive. Moreover, the same time pattern can be observed as the one-period lagged Kaitz difference yields the largest coefficient. The third-period lagged Kaitz difference again has no significant effect on the apprenticeship probability.

Since the mixed logit estimates are not intuitive, table 4 gives the average marginal effects of a minimum wage increase on the probability of apprenticeship training.[13] With all other variables held constant at their mean values, an increase in the one-period lagged Kaitz difference by one unit raises the apprenticeship probability by 7 percentage points in the model with control variables and by 10 percentage points in the model without controls. Recall that the Kaitz difference takes up a sample mean of about 0.04 (see table 2). Multiplying this value with the marginal effects computed here, the apprenticeship probability rises between 0.16 and 0.38 percentage points depending on the lag of the Kaitz difference.

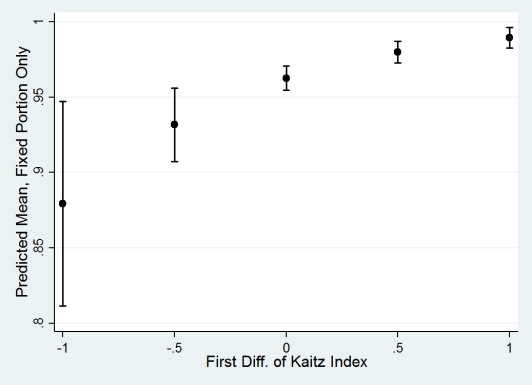
Table 4: Marginal Effects, Baseline Regression (Rounded Values)

Variable	Marginal Effect	Std. Err.	P-Value
	w/o Control Variables (N=8,977)		
Δ Kaitz Index	0.044	0.012	0.000
$(\Delta \text{ Kaitz Index})_{t-1}$	0.070	0.017	0.000
$(\Delta \text{ Kaitz Index})_{t-2}$	0.062	0.020	0.001
	w/ Control Variables (N=6,877)		
Δ Kaitz Index	0.059	0.017	0.001
$(\Delta \text{ Kaitz Index})_{t-1}$	0.101	0.024	0.000
$(\Delta \text{ Kaitz Index})_{t-2}$	0.093	0.030	0.002

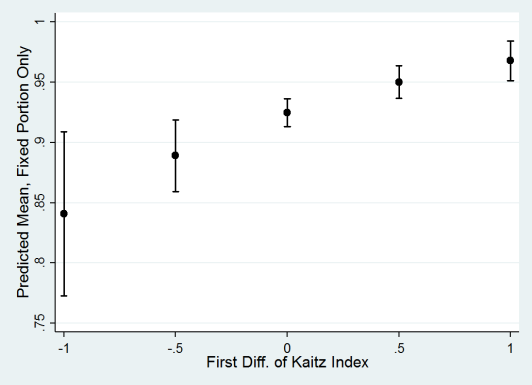
Figure 3 shows the average predicted apprenticeship probabilities at the indicated values of first Kaitz differences.[14] All other exogenous variables are again at their mean values. A strong decline in the minimum wage lowers the apprenticeship probability, yet the predicted value still exceeds 0.75 in all cases.[15] Consequently, the apprenticeship decision is affected but not altered by changing wage prospects.

[13] Person-specific intercepts have to be excluded here in order to calculate a sample average.
[14] The predictions refer to models (1) and (2) in table 3 only.
[15] For the exact values of average predictions, see table B.4 in appendix B.

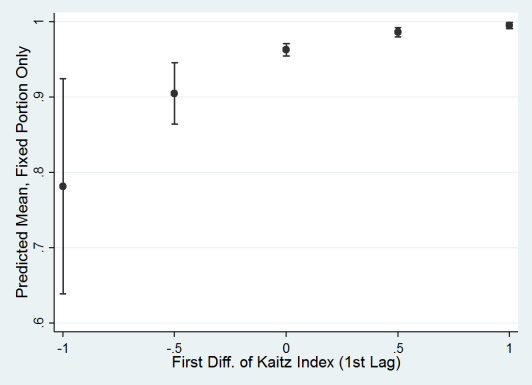
Figure 3: Average Predicted Probabilities



(a) Δ Kaitz, w/o Control Variables

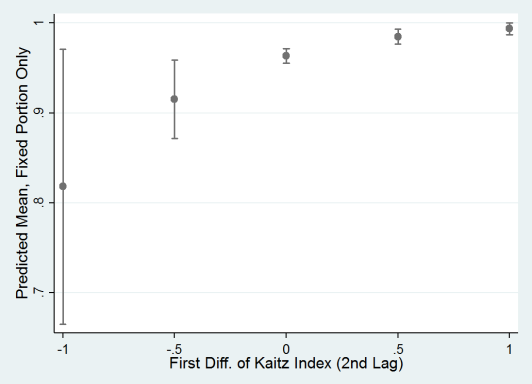


(b) Δ Kaitz, w/ Control Variables

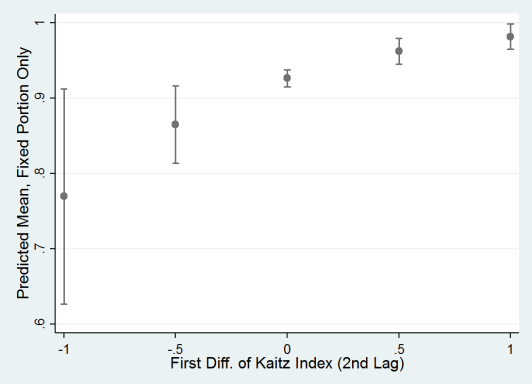


(c) $(\Delta \text{ Kaitz})_{t-1}$, w/o Control Variables

(d) $(\Delta \text{ Kaitz})_{t-1}$, w/ Control Variables



(e) $(\Delta \text{ Kaitz})_{t-2}$, w/o Control Variables



(f) $(\Delta \text{ Kaitz})_{t-2}$, w/ Control Variables

Robustness Checks In order to check whether the observed impact is stable, several robustness tests are conducted. Columns (1) and (2) in table 5 show the estimates for the baseline mixed logit model including the one-period lagged value of the dependent variable. When deciding to undergo professional training, apprentices sign a contract

with a firm which usually comes with a training duration of three years. Thus, once the decision has been made, individuals are likely to keep their status for more than one period. Therefore, it appears appropriate to include the lagged dependent variable as explanatory variable. The resulting coefficients are positive, strongly significant and relatively large. However, the impact of both the current and one-period lagged Kaitz differences is still significantly positive. Adding controls, only the one-period lagged Kaitz difference yields a significant coefficient on a 10% level. Moreover, the size of the coefficients is more than halved compared to the baseline regression. Thus, although the minimum wage effect is statistically observable, it is weak in reality.

Models (3) and (4) present the estimation results including the required skill level to carry out an individual's current occupation. Not surprisingly, the apprenticeship probability is significantly lowered if approved qualifications are not necessary while high qualification requirements promote vocational training.[16] With respect to the first Kaitz differences, the estimates decrease compared to the baseline model but remain positive and mostly significant.[17]

About 7.9% of the observations in the baseline sample belong to the main construction trades,a larger share than for all other minimum wage groups. Not only have sectoral minimum wages been used the longest in this sector, specific technical skills are needed so that apprenticeship training is likely to be opted for (Eichhorst/Marx, 2009). To examine whether the results are driven by this group, the baseline estimation is repeated excluding workers in main construction trades, see table 6. The positive minimum wage impact is stable. The coefficients for the Kaitz differences in t and $t-1$ are significant on a 1% level and in $t-2$ on a 5% level. Notably, the structural time pattern is slightly altered in model (2) as the current Kaitz difference yields the largest estimate.

As mentioned earlier, many sectoral minimum regulations are adapted to regions in order to take account of economic differences. Therefore, a final analysis checks whether region-specific minimum wages also have a region-specific educational impact. The Kaitz differences are interacted with an indicator variable that equals 1 if an individual reports to live in East Germany. The positive educational impact is mainly robust to this sample variation, see table 6.

[16]The estimates for academic education as required are not shown here.

[17]Interaction effects of required education and minimum wage increases did not produce significant coefficients.

Table 5: Alternative Sets of Control Variables

Dep. Variable: Educational Status	(1)	(2)	(3)	(4)
	Lagged Dep. Variable		Required Education	
Educational Status$_{t-1}$	4.056***	3.684***		
	(0.115)	(0.146)		
Δ Kaitz Index	0.798**	0.820**	1.081***	1.077***
	(0.319)	(0.380)	(0.388)	(0.387)
(Δ Kaitz Index)$_{t-1}$	0.798**	0.879**	1.916***	1.942***
	(0.370)	(0.441)	(0.530)	(0.540)
(Δ Kaitz Index)$_{t-2}$	0.802	0.947*	0.835	0.984*
	(0.507)	(0.532)	(0.601)	(0.590)
(Δ Kaitz Index)$_{t-3}$	-0.621	-0.405	-0.775	-0.655
	(0.621)	(0.647)	(0.803)	(0.775)
Sex: Female		-0.121		-0.238
		(0.136)		(0.178)
Nationality: Non-German		-0.634***		-1.054***
		(0.208)		(0.253)
Secondary Degree: Lower		0.510		1.602***
		(0.361)		(0.438)
Secondary Degree: Medium		1.173***		2.861***
		(0.365)		(0.443)
(Δ State Unemployment Rate)$_{t-1}$		0.00472		
		(0.0743)		
(Δ Number of Apprenticeship Places)$_{t-1}$		-0.0418**		-0.00463**
		(0.0199)		(0.00223)
(Δ Relative Youth Cohort Size)$_{t-1}$		-2.246***		0.496***
		(0.618)		(0.149)
Required Education: Orientation			-3.505***	-4.265***
			(0.513)	(0.698)
Required Education: Introduction			-0.664	-1.719**
			(0.516)	(0.692)
Required Education: Course Training			1.003*	-0.451
			(0.543)	(0.711)
Required Education: Professional Training			2.105***	0.847
			(0.476)	(0.659)
Constant	-1.448***	-0.406	-2.959***	1.389*
	(0.183)	(0.441)	(0.578)	(0.749)
Random Intercept (Std. Dev.)	-0.201	0.138	1.100***	0.993***
	(0.148)	(0.125)	(0.0546)	(0.0621)
Observations	6,299	4,111	6,683	5,793
Year Effects	Yes	Yes	Yes	Yes

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; observations are clustered at the individual level.

Table 6: Sample Variations

Dep. Variable: Educational Status	(1)	(2)	(3)
	w/o Main Constr. Trades		Regional Separation
Δ Kaitz Index	1.941***	2.087***	0.796**
	(0.500)	(0.600)	(0.375)
$(\Delta$ Kaitz Index$)_{t-1}$	2.121***	2.084***	1.326**
	(0.620)	(0.683)	(0.555)
$(\Delta$ Kaitz Index$)_{t-2}$	1.699**	1.822**	0.841
	(0.788)	(0.785)	(0.696)
$(\Delta$ Kaitz Index$)_{t-3}$	0.526	0.654	0.0421
	(0.870)	(0.875)	(0.833)
Sex: Female		-0.289	
		(0.209)	
Nationality: Non-German		-1.352***	
		(0.319)	
Secondary Degree: Lower		1.271**	
		(0.505)	
Secondary Degree: Medium		3.066***	
		(0.509)	
$(\Delta$ State Unemployment Rate$)_{t-1}$		0.0129	
		(0.0557)	
$(\Delta$ Number of Apprenticeship Places$)_{t-1}$		-0.00539**	
		(0.00222)	
$(\Delta$ Relative Youth Cohort Size$)_{t-1}$		-0.368*	
		(0.215)	
Region: East Germany			1.566***
			(0.217)
Region: East Germany $\times$ Δ Kaitz Index			1.323*
			(0.721)
Region: East Germany $\times$ $(\Delta$ Kaitz Index$)_{t-1}$			1.433
			(0.944)
Region: East Germany $\times$ $(\Delta$ Kaitz Index$)_{t-2}$			2.186*
			(1.185)
Region: East Germany $\times$ $(\Delta$ Kaitz Index$)_{t-3}$			-0.0761
			(1.385)
Constant	3.470***	1.239***	2.978***
	(0.285)	(0.0365)	(0.268)
Random Intercept (Std. Dev.)	1.526***	1.129***	1.237***
	(0.497)	(0.0559)	(0.0366)
Observations	8,270	4,687	8,977
Year Effects	Yes	No	Yes

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; observations are clustered at the individual level.

Furthermore, the regional analysis reveals two interesting findings. Firstly, the apprenticeship probability of youths in East Germany is significantly higher compared to their West German counterparts. Secondly, the interaction terms partly yield positive estimates which are significant at the 10% level. Thus, a positive minimum wage impact emerges in both parts of the country and it is stronger in East Germany, which potentially results from the relatively weaker macroeconomic environment. Even though wage floors are regionally adapted, they still might affect the East German economy to a greater extent. Thereby, they lead to a stronger decline in employment probabilities of unskilled workers and to further training incentives. A second explanation might be regional disparities of educational preferences. If more school-leavers in West Germany favor university education, maybe due to the fact that it is more easily affordable for families there, the share of East German youths among apprentices is larger. Both of these arguments require further investigation which is beyond the scope of this paper.

6 Conclusion

Contrary to empirical evidence from other countries, we find a positive effect of minimum wages on educational incentives in Germany. As relative sectoral wage floors increase between $t-1$ and t, youths in the affected occupational groups are encouraged to undergo vocational training rather than supplying unskilled labor. The impact is stable to several model variations. Yet, minimum wages do not represent a strongly influencing factor of educational decisions. Given an average increase of a sectoral wage floor, the apprenticeship probability is raised by less than 0.5 percentage points. Even in case of strong, hypothetical reductions of relative minimum wages, the predicted apprenticeship probability still exceeds a value of 0.75 so that training decisions are not altered by rising minimum wages. Although youths take account of wage prospects, these are not a crucial determinant in making occupational decisions.

To explain these observations, we follow the line of argument of the Substitution Hypothesis. The educational effect of a wage floor raise is positive if the associated demand reduction for low-skilled workers outweighs the income effect induced by the higher minimum. This is in line with the *institutional complementarity* of the German labor market. The design of employment relationships aims at particularly employing skilled workers in standard, permanent and full-time contracts (Eichhorst/Marx, 2009). Thus, the effect of a minimum wage raise on employment prospects is likely to outweigh the direct income effect. In light of the highly institutionalized and publicly regulated apprenticeship

system in Germany, occupational skill standards and qualification requirements serve as a more plausible explanation determining training decisions. The observed impact of previously obtained secondary education is in support of this idea. Individuals who signal higher abilities by means of higher school degrees are more likely to pursue an apprenticeship, probably because they are preferred by employers. Since apprenticeship payments are usually exogenous, firms are interested in offering training to the most apt youths only. The higher skill requirements and average qualifications in an occupational group are, the lower is the job finding probability for the unskilled and the costlier is it to forego the accumulation of these skills.

Regarding practical implications, we motivated our analysis by raising the question of necessity of a youth exemption from the statutory minimum wage. In principle, the positive minimum impact we find suggests no need to exempt younger workers. However, the Substitution Hypothesis can again be used to provide an argument in favor of an exception. In response to a minimum wage eligibility of youths, employers might reduce the number of apprenticeship places. With an exemption, on the contrary, apprentices can legally be paid a subminimum which gives them a cost advantage over unskilled adults. Hence, employers face incentives to offer even more apprenticeship places. An exemption for apprentices might thus promote both substitution behavior and vocational training. From a point of view of education policy, a youth exemption from minimum wages can still be classified as reasonable in order to protect or even enhance opportunities for vocational training. However, if employers substitute low-skilled adult workers with apprentices, the exemption implies job losses among the latter. To accept these or to even purposely use the competitive advantage as a device to promote skill acquisition among youths appears at least questionable.

It still remains to examine whether the results can be generalized to all forms of wage floors. This point is of special importance since the youth exception discussed above is implemented for the new statutory minimum wage. Due to a higher degree of affection or spillover effects, educational incentives might be impacted in a different way. In addition, as the observations are shaped by the idiosyncratic German system of vocational training, they might lack international generalizability. There is a need for internationally comparative research in order to verify our results.

Despite the fact that we make certain contributions to the analysis of minimum wage effects, some questions are left unanswered. Firstly, it might be worthwhile to investigate potential minimum wage impacts on the horizontal occupational decision, that is, to

answer the question whether youths prefer an occupation to which a sectoral wage floor applies over one that is not affected by public intervention. Secondly, the impact of the statutory minimum wage on decisions regarding apprenticeship training must be scrutinized in order to give an appropriate recommendation regarding a youth exemption. If our result of a non-distorting educational effect is confirmed, a general eligibility would be preferable in order to avoid job losses among low-skilled adult workers. Yet, due to the short period of the statutory miminum wage being in effect, a qualitatively appropriate amount of data will only be available in a few years time.

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A Dataset Description

Survey Year. Year of observation, 1994 to 2014.

Educational Status. Occupational alternatives for school-leavers aged 17 to 24 without higher secondary degrees or professional degrees, i. e. *Unskilled Full-Time or Part-Time Work* (0), *Doing an Apprenticeship* (1).

Minimum Wage. Gross hourly generally binding sectoral or occupational minimum wage in € valid on January 1 of the respective observation year.

State Median Wage. Median of gross hourly wages in € on the federal state level. Represents the median of all workers' wages including part-time and marginally employed persons and apprentices.

Kaitz Index. Ratio of the sectoral minimum wage to the median wage in the individual's state of residence.

Sex. Indicator: Male (0), Female (1).

Nationality. Indicator: German (0), Non-German (1).

Secondary School Degree. Secondary school degree obtained by an individual excluding higher secondary degrees: No Degree (0), Lower Degree (1), Medium Degree or Other Degree (2).

Required Education for Occupation. Skill level required to carry out an individual's current occupation: *None* (1), *Orientation* (2), *Introduction* (3), *Course Training* (4), *Professional Training* (5), *Academic Training* (6).

Region of Residence. Indicator: West Germany (0), East Germany (1).

State Unemployment Rate. Number of registered unemployed persons as percentage of civil employees on the federal state level.

Number of Apprenticeship Places. Number (in thousands) of officially registered apprenticeship places on September 1 of the observation year on the national level.

Relative Youth Cohort Size. Number of youths aged 17 to 24 as percentage of total population on the national level.

B Addendum to the Regression Analysis

Table B.1: Association of Occupations with Minimum Wages

Label of Occupational Group	Codes FSO-1992-Classification
Building Cleaning	9340-9343, 9349
Butchery	400-4017
Care Nursing	8640-8657
Chimney Sweep Trades	8040-8042
Electrical Trades	3100-3152, 3157-3177, 3200-3229
Hair Dressing	9010-9019
Hard Coal Mining	700-727
Main Construction Trades	4000-4429, 4600-4889, 5440, 5446-5469
Laundry Services	9300-9359
Painting & Varnishing	5100-5149
Postal Services	7300-7354
Professional Education	8680-8682, 8769, 8855, 8856
Roofing	4880-4889
Scaffolding	4430-4437
Security Services	7900-7912, 7920-7929
Stone Cutting	1000-1019
Waste Management	9350-9359

Table B.2: Baseline Collinearity Diagnostics

Variable	VIF	$\sqrt{VIF}$	Tolerance	R-squared
Educational Status	1.05	1.02	0.9542	0.0458
Δ Kaitz Index	1.08	1.04	0.9288	0.0712
$(\Delta$ Kaitz Index$)_{t-1}$	1.15	1.07	0.8707	0.1293
$(\Delta$ Kaitz Index$)_{t-2}$	1.14	1.07	0.8751	0.1249
$(\Delta$ Kaitz Index$)_{t-3}$	1.08	1.04	0.9254	0.0746
Sex	1.18	1.09	0.8455	0.1545
Nationality	1.06	1.03	0.9471	0.0529
Secondary School Degree	1.07	1.03	0.9343	0.0657
$(\Delta$ State Unemployment Rate$)_{t-1}$	1.03	1.02	0.9692	0.0308
$(\Delta$ Number of Apprenticeship Places$)_{t-1}$	1.12	1.06	0.8966	0.1034
$(\Delta$ Relative Youth Cohort Size$)_{t-1}$	1.04	1.02	0.9591	0.0409
Time	1.12	1.06	0.8928	0.1072
Economic Sector According to NACE	1.14	1.07	0.8747	0.1253
Mean VIF	1.10			

Table B.3: Cross-Correlation Diagnostics

Variables	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11
Educational Status (v1)	1.000										
Δ Kaitz Index (v2)	0.023	1.000									
(Δ Kaitz Index)$_{t-1}$ (v3)	0.046	-0.174	1.000								
(Δ Kaitz Index)$_{t-2}$ (v4)	0.032	-0.053	-0.185	1.000							
(Δ Kaitz Index)$_{t-3}$ (v5)	-0.019	-0.008	-0.075	-0.199	1.000						
Sex (v6)	-0.015	-0.095	-0.080	-0.059	-0.033	1.000					
Nationality (v7)	-0.159	-0.013	-0.024	-0.021	-0.002	-0.005	1.000				
Secondary School Degree (v8)	0.176	-0.030	0.009	0.012	-0.001	0.095	-0.149	1.000			
(Δ State Unemployment Rate)$_{t-1}$ (v9)	-0.028	-0.033	-0.016	-0.019	-0.010	0.002	0.021	-0.078	1.000		
(Δ Number of Apprenticeship Places)$_{t-1}$ (v10)	-0.023	0.023	0.016	-0.019	-0.001	-0.007	-0.006	-0.016	-0.161	1.000	
(Δ Relative Youth Cohort Size)$_{t-1}$ (v11)	0.003	0.004	0.114	-0.005	0.027	0.008	0.012	0.030	-0.192	0.098	1.000

Table B.4: Average Predicted Probabilities

Cut-Off Value	Average Prediction	
	w/o Control Variables	w/ Control Variables
Δ Kaitz Index = -1	0.8793018	0.8408154
Δ Kaitz Index = -0.5	0.9317046	0.8890496
Δ Kaitz Index = 0	0.962606	0.9246948
Δ Kaitz Index = 0.5	0.9799292	0.9500976
Δ Kaitz Index = 1	0.9893493	0.9676293
$(\Delta \text{ Kaitz Index})_{t-1}$ = -1	0.781735	0.7480607
$(\Delta \text{ Kaitz Index})_{t-1}$ = -0.5	0.9050284	0.8570644
$(\Delta \text{ Kaitz Index})_{t-1}$ = 0	0.9628654	0.9253877
$(\Delta \text{ Kaitz Index})_{t-1}$ = 0.5	0.9862093	0.9636856
$(\Delta \text{ Kaitz Index})_{t-1}$ = 1	0.9949869	0.9832987
$(\Delta \text{ Kaitz Index})_{t-2}$ = -1	0.8180558	0.769643
$(\Delta \text{ Kaitz Index})_{t-2}$ = -0.5	0.9152427	0.8650432
$(\Delta \text{ Kaitz Index})_{t-2}$ = 0	0.9634797	0.9263264
$(\Delta \text{ Kaitz Index})_{t-2}$ = 0.5	0.9848813	0.9621259
$(\Delta \text{ Kaitz Index})_{t-2}$ = 1	0.9938547	0.9814643

Figure B.1: Wages and Unemployment Rates over Federal States

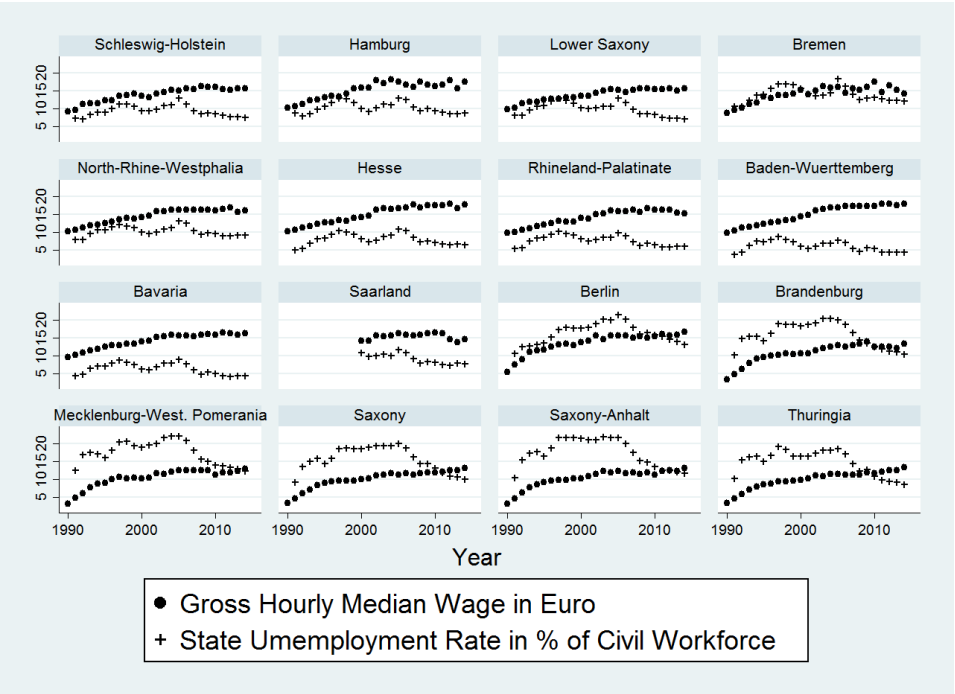
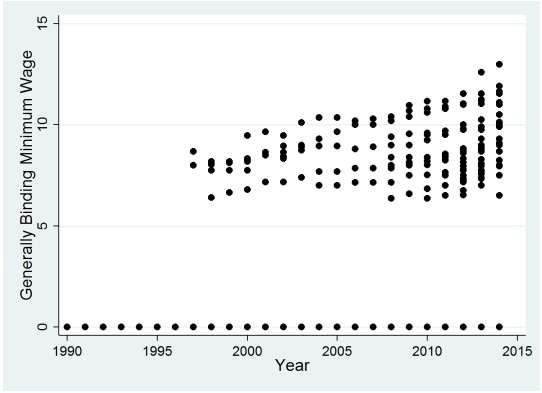
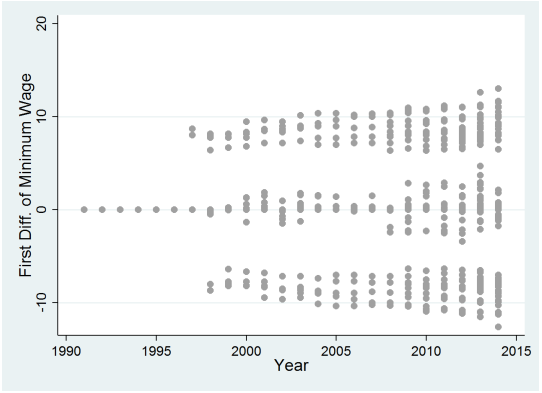


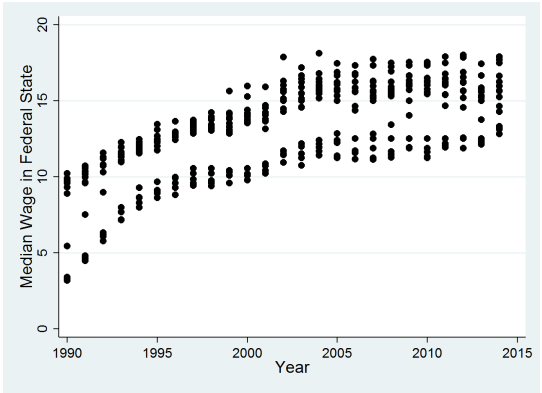
Figure B.2: Minimum Wages and State Median Wages, 1990-2014



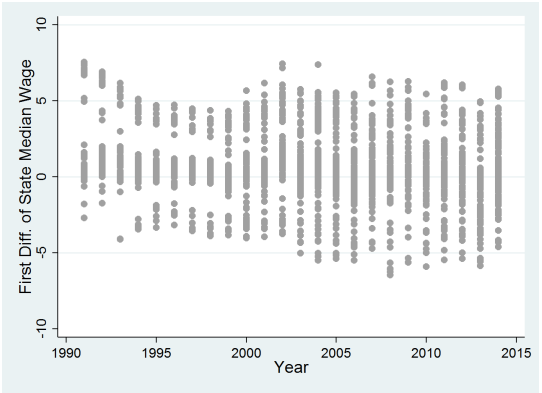
(a) Minimum Wage



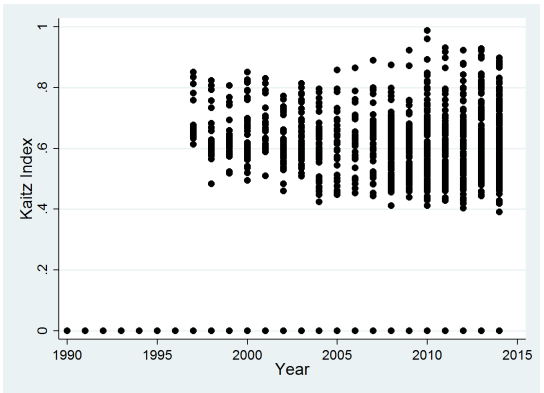
(b) Δ Minimum Wage



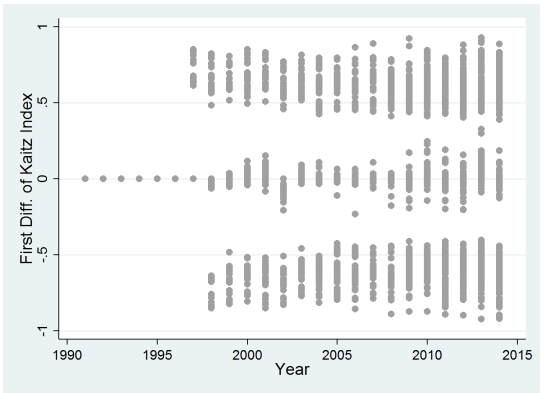
(c) State Median Wage



(d) Δ Median Wage



(e) Kaitz Index



(f) Δ Kaitz Index

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